What is This Report?

This status report updates the Department of Energy's (DOE) Environmental Management (EM) program life-cycle cost and schedule estimates for completing cleanup, which EM last provided in the 1998 *Paths to Closure* report. EM is issuing this status report now to discuss recent trends in its life-cycle cost and schedule estimates and to introduce additional analyses that offer new insights into the long-term scope of the program. This status report is based on life-cycle cost and schedule data that EM collected in 1999. The estimated schedules for completing environmental management activities (not including long-term stewardship) have been adjusted to be consistent with the FY 2001 budget request.

This report is not a budget analysis that justifies or challenges any level of funding. Although many issues addressed in this document may inform future budget planning, these latest life-cycle cost estimates, the analysis of project uncertainties, and other project analyses included in this report are intended to be management tools to improve EM program implementation. These tools are designed to enable decision makers and stakeholders to understand the possible impacts of different resource and policy choices more clearly. Among these choices are opportunities to reduce life-cycle costs by further accelerating work, or delay work if future budgets decline.

Typically, life-cycle cost estimates address the full duration of a program, from its inception until all activities are completed. For purposes of this report, the life-cycle cost estimates presented do not include the approximately $35 billion in costs incurred by EM from the program's inception in 1989 through FY 1996. Rather, the life-cycle estimates provided in this status report include EM's costs from FY 1997, when EM began focusing on the completion of cleanup and closure of sites, through 2070. All costs are in 1999 constant dollars unless otherwise noted.

Introduction

The EM program[1] is responsible for addressing the environmental legacy of nuclear weapons research, production, and testing and of DOE-funded nuclear energy and basic science research in the United States. These activities collectively produced large volumes of nuclear materials, spent nuclear fuel, radioactive waste, and hazardous waste, resulting in contaminated facilities, soil, and groundwater at 113 sites around the country.[2]

EM manages some of the most technically challenging and complex work of any environmental program in the world. For example, the EM program is responsible for:

- remediating 1.7 trillion gallons of contaminated ground water, an amount equal to approximately four times the daily U.S. water consumption;
- remediating 40 million cubic meters of contaminated soil and debris, enough to fill approximately 17 professional sports stadiums;

- safely storing and guarding more than 18 metric tons of weapons-usable plutonium, enough for thousands of nuclear weapons;
- managing over 2,000 tons of intensely radioactive spent nuclear fuel, some of which is corroding;
- storing, treating, and disposing of radioactive and hazardous waste, including over 160,000 cubic meters that are currently in storage and over 100 million gallons of liquid, high-level radioactive waste;
- deactivating and/or decommissioning about 4,000 facilities that are no longer needed to support active DOE missions;
- implementing critical nuclear non-proliferation programs for accepting and safely managing spent nuclear fuel from foreign research reactors that contains weapons-usable highly enriched uranium; and
- providing long-term care and monitoring—or stewardship—for potentially hundreds of years at an estimated 109 sites following cleanup.

Despite the complexity and size of its mission, EM has made substantial progress. At the start of FY 2000, EM had completed active cleanup at 69 of the 113 sites.[3] Since 1997, EM has been implementing a site closure initiative to improve program management, accelerate and complete cleanup, close as many sites or portions of sites as possible by 2006, and reduce life-cycle costs at the remaining sites. By shortening the time frame during which the fixed costs associated with maintaining the infrastructure of a site—a major component of EM's overall costs—must be borne, life-cycle costs can be significantly reduced. This status report reaffirms EM's intent to complete as much cleanup as possible by 2006 and reduce EM infrastructure costs at each site as expeditiously as possible.

Much of EM's costs for maintaining site infrastructure (e.g., security, ventilation controls, and roof maintenance) are necessary to protect the safety of the workers and others on and near the sites. Aside from these costs for maintaining critical site infrastructure, the largest portion of EM's budget is directed toward ensuring compliance with the large number of legally-enforceable cleanup and compliance agreements that EM has in place at all of its major sites in 14 states. Because these non-discretionary duties (i.e., safety and compliance) account for approximately 85 - 90 percent of the EM budget, there is often little flexibility with how funding is allocated to DOE sites.

The closure strategy, in conjunction with other factors, such as closer cooperation with regulators and communities, has started to pay off. Accelerated schedules for completing the cleanup of the Rocky Flats Environmental Technology Site in Colorado (Rocky Flats) and the Miamisburg Environmental Management Project (formerly the Mound Site) in Ohio demonstrate the success of focusing on closure. In the last five years, the completion date for each site has moved forward significantly. At Miamisburg, the completion date has been brought forward from 2030 in 1996[4] to a target of 2004 in this latest analysis. At Rocky Flats, the schedule has been moved forward from 2060 in 1995[5] to a target date of December 2006. EM and its contractors have accomplished these schedule reductions at Rocky Flats and Miamisburg by reevaluating the site operating plan, finding more efficient ways to plan and conduct environmental work, working more effectively with stakeholders and regulators, and clarifying the end states that environmental cleanup work will achieve.

EM's evaluation of the 1999 life-cycle cost data also shows that, at sites focused on completing environmental activities in the near future, EM has dramatically reduced life-cycle cost estimates when compared with similar estimates made as recently as 1995. For example, the estimate of life-cycle costs for Rocky Flats, which includes scope differences, has dropped by more than $25 billion—from more than $36 billion in 1995[6] to less than $8 billion in the most recent estimate.

At sites across the country, similar reasons underlie the success of EM's focus on completing work. First, EM and its contractors better understand the scope of work required at these closure sites, thus enabling them to make more realistic cost and schedule projections. This improved understanding, however, should not be misinterpreted to mean that there is no remaining uncertainty at these sites. Many technically complex projects still pose significant cost and/or schedule challenges.

Second, EM has executed performance- and incentive-based contracts to ensure that cost and schedule estimates are more likely to be met. For example, at Rocky Flats, EM recently executed a new closure contract that provides incentives to accomplish work at or below the already reduced current life-cycle cost and schedule estimates. In addition, EM is planning to execute a similar contract at the Fernald Environmental Management Project (Fernald) in Ohio this year. At other sites, such as the Oak Ridge Reservation in Tennessee, new contracts are stressing the use of competitive subcontracts to help reduce costs.

Third, a focus on closure by EM, regulators, and stakeholders has helped to resolve difficult issues and has produced innovative management approaches, including more effective management systems to hold contractors and staff accountable for meeting cost and schedule baselines. Increased attention to closure has also spurred the use of new technologies and flexible regulatory approaches to achieve greater efficiencies.

Despite these successes, EM still faces formidable tasks that are likely to require $168 - $212 billion to complete.[7] These estimates are of approximately the same magnitude as previous life-cycle cost estimates that EM has prepared to assess the program's environmental obligations. Fulfilling EM's mission will require an even greater focus on finding cost-effective implementation strategies such as integration of nuclear materials and waste management options; continuing to use the best available science and technology; and working more closely with Federal and state regulators, Tribal Nations, local governments, and citizens.

Evolution of Life-cycle Estimates

To help plan and implement an effective cleanup program, EM uses life-cycle cost analysis as one of its management tools. Life-cycle cost analysis for environmental management and remediation programs provides policymakers and stakeholders with a broad context to make major policy choices and the range of estimated total funding that will be needed to complete a job. This type of analysis also helps to identify areas of a program that require more detailed management attention and helps to set broad, strategic priorities. The results of such analyses, however, are imprecise. The future costs of many complex environmental management and remediation programs are difficult to quantify with precision, particularly when many projects remain in a planning stage. As project planning progresses, and more is known about what will be required to implement a project, cost estimates, and consequently schedules, may significantly increase or decrease. Management studies show that complex environmental programs, along with other first-of-a-kind projects, have some of the greatest variability in life-cycle cost estimates.

This report, which updates EM's 1998 Paths to Closure report[8], evolved from previous efforts to estimate the program's life-cycle costs. In 1995, EM developed the Baseline Environmental Management Report (BEMR). The 1995 BEMR estimated total DOE cleanup costs and included estimates for the infrastructure and support costs of managing sites. It also estimated the cost of several alternative cleanup scenarios with varied land uses or accelerated schedules. EM updated the BEMR in 1996, using more detailed data from its field offices, and re-examining the effects of various program alternatives on life-cycle costs.

Taken together, the 1995 and 1996 BEMR reports were EM's first post-Cold War attempt to understand the full magnitude of the program's environmental problems, the life-cycle costs for addressing these problems, and costs for alternative end states. Two key BEMR findings were that a large portion of EM costs support ongoing facility maintenance while cleanup is occurring, and that cleanup to allow for unrestricted use is not possible at many sites because of technical and financial limitations.

These previous estimates suggested that DOE needed to find ways to reduce the program's costs to more manageable levels and to accelerate schedules. Therefore, the 1998 Paths to Closure report articulated the vision of reducing the overall program cost by accelerating cleanup, completing projects, and closing sites, with a goal of achieving as much as possible by 2006. The 1998 Paths to Closure report examined the cost savings to be realized by completing cleanup as expeditiously as possible, and demonstrated that the greatest cost savings could be realized by eliminating site infrastructure and support services, and by closing sites. EM refers to this near-term strategy to reduce site infrastructure and support services as reducing its "mortgage."

A 1999 General Accounting Office (GAO) study on the 1998 Paths to Closure report[9] recognized both the strengths and weaknesses of that report. GAO noted that EM's new life-cycle methodology resulted both in improvements in EM's life-cycle planning capabilities and in limitations, largely because of its first time use. In particular, the GAO report noted that a strength of the 1998 Paths to Closure report was having EM field offices define project scope and an optimal sequence for implementing work. Using this newly defined project scope, the field offices generated schedules and life-cycle cost estimates for each project. These estimates are the baselines against which cost and schedule changes can be measured.

A key limitation of the 1998 Paths to Closure report noted by GAO was that the scope of work for many of these projects was not yet well understood or could not be verified from supporting information. This observation was particularly true for the most complex and technically challenging projects, such as high-level waste management at the Idaho National Engineering and Environmental Laboratory, the Hanford Site in Washington State, the

Savannah River Site in South Carolina, and the West Valley Demonstration Project in New York. In other cases, the scope of work defined as the basis for the costs in the 1998 Paths to Closure report was incomplete. For example, the data used to support the 1998 report included a limited discussion of the costs associated with long-term stewardship, an area for which EM is just beginning to gather data more systematically. In addition, costs for most projects included in the 1998 Paths to Closure report did not reflect cost uncertainties that exist in project plans.

Given these factors, and EM management's challenge to field offices and contractors to reduce costs as much as possible, the overall life-cycle cost estimate of the 1998 Paths to Closure report was understandably incomplete and consequently understated the likely life-cycle cost estimate of the program.

Focus of This Status Report

To prepare this status report, EM conducted several analyses to build on the work done in the 1998 Paths to Closure report. For example, in 1998, project cost estimates generally did not include the costs of a project's technical uncertainties. Without an estimate of the cost impact of these uncertainties, the sum of the 1998 baseline project estimates did not represent a realistic estimate of the EM program's life-cycle cost. To address this issue, EM analyzed the likely costs associated with the many uncertainties that still remain in individual projects. A description of the methodology for this analysis is found in Appendix A. This analysis estimated the amount of uncertainty in three areas that could affect future costs: 1) current state of project definition; 2) innovation; and 3) project complexity. EM field offices supplied information for this analysis, the results of which provide a better understanding of overall program life-cycle cost estimates. The uncertainty analysis affirms that life-cycle costs are more appropriately presented as a range of estimates than as a single point estimate.

The 1999 data supporting this status report are more complete than the 1998 data because of more detailed EM headquarters guidance and the EM field offices' response. As a result, this status report is based on a more mature understanding of the scope of work for specific projects that likely will be required to meet EM's environmental cleanup obligations.

For example, as a result of several national and site-wide project management initiatives since the 1998 Paths to Closure report, many EM field offices have modified the scope of work or identified more aggressive approaches to conducting their work scope. Overall, these initiatives have improved the quality of EM project baselines. For a few projects, these reviews led to reduced life-cycle cost estimates. For most projects, however, life-cycle cost estimates increased because the management initiatives resulted in improved understanding of project requirements, uncertainties, and costs. For example, at the Idaho National Engineering and Environmental Laboratory, project costs for high-level waste management increased by $735 million after incorporating recommendations from a U.S. Army Corps of Engineers review and a feasibility study for the High Level Waste Immobilization Facility. These types of estimates reflect a better understanding of project scope and are representative of improvements since the 1998 Paths to Closure report.

The data collected since 1998 also provide EM with a better cost estimate of long-term stewardship costs through 2070. The 1998 Paths to Closure report included approximately $5 billion for long-term stewardship costs through 2070, but only for sites that reported such costs. For 1999, nearly all of the field offices reported preliminary scopes of work and costs associated with long-term stewardship. The comparable life-cycle costs of these stewardship estimates through 2070 are approximately $10 billion. For example, Fernald estimates that approximately $400 million in constant 1999 dollars will be needed for stewardship through 2070 given the site's currently anticipated end state and future land uses. The total EM estimate of approximately $10 billion for long-term stewardship through 2070 will likely change over time as sites move further into the cleanup process and are able to define the nature and scope of stewardship requirements more clearly.

Finally, in support of this status report and other initiatives, EM has continued to develop and refine its data and information management systems to provide better tools and enable improved analysis of costs and schedules. The data serving as the basis for this status report are part of an integrated planning system that provides EM with a more systematic approach to understanding the wastes that must be managed, the costs and schedules that are planned, and the progress that is made toward meeting planning targets.

Range of Life-cycle Cost Estimates for Sites in the EM Program

As noted previously, because the data supporting this status report were collected in 1999, they do not necessarily reflect current baselines or funding profiles at EM's sites. The data do not include changes that resulted from actual FY 2000 appropriations or anticipated changes as a result of both the FY 2000 supplemental and FY 2001 budget requests. For example, EM's activities in Portsmouth, Ohio and Paducah, Kentucky have already received significant funding increases in FY 2000. In addition, EM has submitted a supplemental budget request in FY 2000, as well as requested substantial increases for these two sites in FY 2001. The impact of these funding increases is not reflected in this analysis.

The only data updated since 1999 are a few schedule estimates that reflect changes in site completion dates. Adjustments to schedule estimates are consistent with the FY 2001 budget request (see Appendix B and its accompanying footnotes). The life-cycle cost data will be updated in the spring of 2000. The cost and schedule data supporting this status report for each EM project, including the baseline life-cycle cost estimate, a description of the work to be completed, and project status summaries for each site, are found on the companion Internet site: www.em.doe.gov/closure.

Based on the 1999 data, EM's life-cycle cost estimate for FY 1997 through FY 2070 ranges from approximately $168 - $212 billion.10 This range includes the approximately $17 billion in costs already incurred in FY 1997 through FY 1999. If these costs were not included, life-cycle cost estimates would range from $151 - $195 billion. Overall, although there are scope differences, the current life-cycle cost estimate is roughly the same magnitude estimated by the two BEMRs—about $200 billion plus or minus 10 - 15 percent.11 Exhibit 1 summarizes EM's life-cycle cost estimate range.

Exhibit 1

Basis for Life-cycle Cost Estimate for EM Program

Category	Life-cycle Cost Estimate Including FY97 - FY99 Incurred Costs ($ in billions of constant 1999 dollars)	Life-cycle Cost Estimate Excluding FY97 - FY99 Incurred Costs ($ in billions of constant 1999 dollars)
Sum of Field Generated Baseline Life-cycle Cost Estimates	$168	$151
Range of Probable Life-cycle Cost Estimate from Uncertainty Analysis Model	$184 - $212	$167 - $195
EM Life-cycle Cost Estimate	$168 - $212 (FY 1997 - FY 2070)	$151 - $195 (FY 2000 - FY 2070)

Note: The estimates in this Exhibit do not include the approximately $35 billion in EM costs from 1989 through FY 1996, which would result in a total life-cycle cost of the program of approximately $203 - $247 billion ($35 billion + $168 billion to $212 billion).

The lower end of this range is the sum of the costs of the planning baselines for individual projects (i.e., the cost estimates that the field offices provided). However, for most projects this lower cost generally does not include an estimate for the uncertainties and the risks of completing the projects for this amount. EM considers the lack of an estimate of project uncertainties to be inappropriate for identifying life-cycle costs. As DOE Under Secretary Moniz has testified on such complex projects as the removal of spent nuclear fuel from K-Basins at the Hanford site: "We believe the only prudent project management solution is to include both cost and schedule contingencies. Without this, we cannot develop a schedule with a high degree of confidence..." For this reason, EM will continue to work to identify project uncertainties and include them in baselines, as appropriate. Appendix B summarizes both the costs of the planning baselines at the site level and the estimated schedules for completing environmental management activities.

The upper end of the range, however, includes a general estimate of cost uncertainty. As noted earlier, the uncertainties evaluated include the likelihood that costs will increase as more is learned about the work to be done, particularly for technically complex projects. The analysis also evaluated cost uncertainties as first-of-a-kind technologies are employed, where the costs to implement projects actually are higher than originally estimated until a new technology can be better understood and deployed.

On the other hand, the uncertainty analysis (and hence the range of costs) also takes into account the possibility that the cost savings EM has found at some sites—efficiencies gained through optimization of work sequencing and elimination of unnecessary work scope—could be more broadly realized across many EM sites. Additionally, some cost reductions are expected to be realized as a result of returns on effective investments in science and new technology. On the whole, however, the results of this analysis show that, given the type and size of uncertainties in EM's projects, the likely overall impact will be a cost increase above the sum of baseline project cost estimates that the field offices provided. Although not addressed in the analysis, there may be corresponding schedule extensions.

This life-cycle cost estimate represents most, but not all, of DOE's potential future environmental liabilities. Additional liabilities not factored into the current estimate include: the costs of managing, decontaminating, and decommissioning active and surplus facilities not currently managed by the EM program, such as the gaseous diffusion plants managed by the U.S. Enrichment Corporation (USEC) and inactive naval reactor facilities; and dispositioning excess plutonium, highly enriched uranium, and depleted uranium managed by USEC. This status report does not include the environmental costs currently paid by other DOE programs such as the Offices of Science; Nuclear Energy, Science, and Technology; or Defense Programs. It also does not include life-cycle cost estimates for a high-level waste geologic repository; high-level waste fees; or long-term stewardship costs for sites cleaned up under the Formerly Utilized Sites Remedial Action Program (FUSRAP) or nuclear fuel cycle facilities under the Nuclear Waste Policy Act Section 151 (b) or (c).

The EM program may become responsible for deactivation and decommissioning (D&D) of many of the contaminated facilities now being managed by other programs when these facilities become excess to the Department's mission. The Department of Energy's Accountability Report: Fiscal Year 1999[12] estimates the cost of D&D of contaminated active and surplus facilities outside of the EM program to be about $25 billion. As noted above, these costs also are not included in the life-cycle cost range in this report.

EM Vision of Emphasizing Closure Shows Success

As noted earlier, EM's site closure and completion strategy is beginning to pay off. As a result of this strategy, the life-cycle cost estimates for completing EM work at sites in the Defense Facilities Closure Projects Account have, in many cases, been reduced substantially since estimates made in the mid-1990s.

Since the 1998 Paths to Closure report, however, the life-cycle cost estimates for some of these sites have increased somewhat. For example, while the cost of completing work at Rocky Flats has remained the same (i.e., approximately $6.3 billion in constant 1999 dollars), the total life-cycle cost estimate has increased because of a better understanding of the site's post-closure costs (now estimated to be $1.4 billion in constant dollars until 2070—a cost not included in the 1998 estimate). The costs of completing the work at sites in Ohio, such as the Fernald Environmental Management Project and the Miamisburg Environmental Management Project, have also increased as new environmental problems have been identified and the field office has developed more complete scopes of work.

The schedules for some sites nearing closure remain essentially the same or show only slight delays. In fact, compared to the 1998 Paths to Closure report, Rocky Flats and the Grand Junction Project Office in Colorado, now estimate that they may be able to accelerate their completion dates by a year or more as a result of re-scheduling or re-baselining their anticipated work. On the other hand, the schedules for some other sites nearing closure have slipped by a year or more, primarily due to unexpected technical issues, discovery of additional waste, or additional regulatory requirements.

Meeting the latest cost and schedule estimates at the sites nearing completion is a substantial challenge. Several projects at Rocky Flats, Fernald, and Miamisburg face major technical risks, and EM still must make many critical decisions in order to meet its objectives. For example, several key challenges—including regulatory challenges—that remain at all three sites involve moving all of the nuclear materials from these sites to other DOE facilities that are capable and ready to accept these materials. EM also faces substantial challenges in determining how to clean up still dangerous wastes located in buildings and storage structures. Future baseline cost estimates will reflect the likely cost impacts of these remaining challenges more accurately.

Trends at Sites With Longer-Term Environmental Missions

EM's capability to estimate life-cycle costs and schedules for some long-term projects and for sites with a long-term environmental mission is limited—as is the case with long-term cost estimates for any program over similar periods of time. In many ways, attempting to estimate the magnitude of these costs with precision is similar to someone 20 years ago trying to estimate the dramatic changes in costs of computers today. The possibility of significant technological advances is an example of the types of cost uncertainty that EM faces, as are the large number of issues associated with waste characterization and political variables that ultimately determine EM's program direction. These uncertainties are a main reason why this status report relies on a range of estimates rather than a single point estimate.

For some sites outside the Defense Facilities Closure Projects Account, current cost estimates are higher than the results EM presented in previous analyses. In large part, these cost increases are due to schedule extensions, which often lead to higher life-cycle cost estimates for infrastructure and other fixed expenses, and cost changes resulting from a better understanding of the work needed to complete several large projects. The results suggest that at these sites, EM will continue to face significant project management and technical challenges for many years.

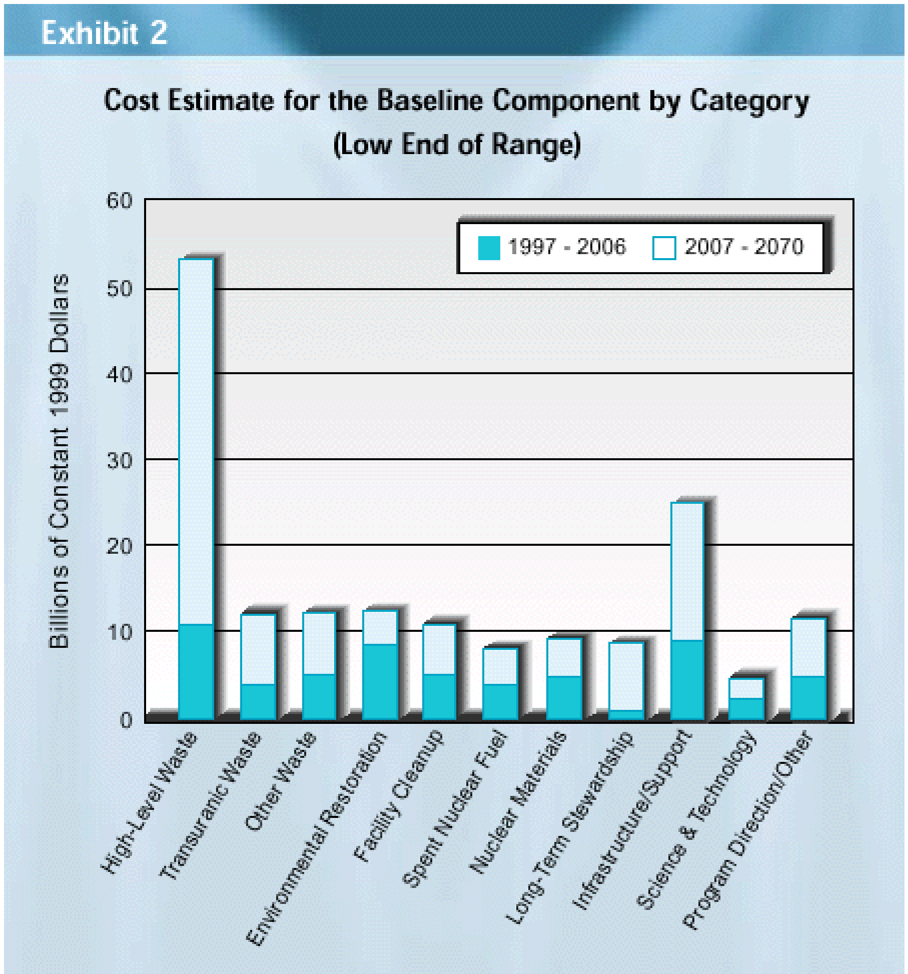
In addition to cost increases, this status report shows that schedules for some sites have slipped from those estimated in the 1998 Paths to Closure report. However, most of the delays in estimated completions are two years or less. With respect to the estimated extension of work at Portsmouth in Ohio from 2005 to 2013 or Paducah in Kentucky from 2010 to 2012, EM has already received additional funding in FY 2000, is seeking a supplemental appropriation in FY 2000, and is seeking even larger increases in FY 2001 to shorten these schedules and bring them closer to the original completion estimates.

EM is seeking to improve the management of these large projects. For example, through an ongoing series of project management initiatives, EM has made efforts to re-baseline projects and to identify and achieve project efficiencies. As a result of these efforts, costs and schedules for projects at these sites have been better defined and, in a few cases, even reduced.

In a few cases where projects are facing delays and cost increases, the delays are caused by regulatory circumstances over which EM has little control. For example, delays in opening the Waste Isolation Pilot Plant (WIPP) have lengthened the life-cycle schedule for operating the facility and increased the corresponding life-cycle cost estimates by over $100 million. A change in a regulatory decision at the Kansas City Plant (i.e., from an initial decision to take no action on an area to the current plan to remediate the area) resulted in a schedule delay in completing environmental restoration by five years and increased costs by $20 million (out of a total life-cycle cost estimate of $114 million, or a 17 percent increase). In other cases, such as at the Sandia National Laboratories in New Mexico, DOE discovered additional contamination that resulted in a delay in completing work and additional costs of $40 million (out of a total life-cycle cost estimate of $284 million, or a 14 percent increase). Although these examples are small relative to the total life-cycle cost estimate of the EM program, they are significant for the individual sites and illustrate the kinds of circumstances that give rise to unexpected cost increases.

The major cost increases at these sites, however, are associated with 18 EM projects or groups of projects that had life-cycle cost estimate increases of $500 million or more. Overall, the sum of the life-cycle cost estimates of the project baselines has increased by approximately $17 billion (or 11 percent) from the 1998 Paths to Closure report.

As shown in Exhibit 2, high-level waste projects account for nearly one-third of the low end of EM's cost estimate (more than $50 billion of the approximately $168 billion this report estimates as the low end of the estimated life-cycle cost range). The largest cost uncertainties and largest increases in cost since the 1998 life-cycle estimates stem from non-traditional environmental cleanup projects to treat and dispose of high-level wastes, spent nuclear fuel, or excess nuclear materials at the Idaho National Engineering and Environmental Laboratory, the Hanford Site, and the Savannah River Site. Changes since 1998 in life-cycle cost estimates for these projects result from EM's improved understanding of the full scopes of work required to manage these wastes and the increased costs of new technical approaches for some projects when existing plans prove to be no longer feasible based on additional design or testing. For example, the 1999 data show a $2 billion life-cycle cost increase (in constant 1999 dollars) for managing the spent nuclear fuel and high-level waste at the Savannah River Site. Other changes are associated with new technical approaches for required work or delays in plans to implement a scope of work due to delays in opening management facilities.



To reduce these costs and successfully address these long-term problems, investments in science and technology are critical. Life-cycle cost analysis is helping to focus some of the program's science and technology investments. Exhibit 2 shows that more than two-thirds of the EM life-cycle cost estimate is expected to be incurred after 2006. About 30 percent of this amount—the single greatest category of life-cycle cost—is attributable to managing high-level waste. The long time frame for spending is a major reason for DOE's continuing need to make science and technology investments that can reduce life-cycle costs. Consequently, EM's Office of Science and Technology is now spending over 30 percent—about $60 million in FY 2000—of its budget on addressing high-level waste management challenges.

EM has already seen results from its investment in science and technology. For instance, during the last three years, EM projects have increasingly employed new technologies—over 129 first-time deployments of new technologies funded by EM's Office of Science and Technology, including 77 in 1999 alone. These technologies are helping to solve both EM's near-term and long-term problems. Successful remediation of over 50 contaminated sites has occurred through use of innovative technologies such as chemical washing, in-situ bioremediation, and vapor extraction and treatment of nonaqueous liquids. Cost reduction benefits have also accrued from innovative technology use. In the case of high-level waste, a pretreatment "system" of three innovative technologies was used to successfully remove approximately 33,000 gallons of liquid waste at Oak Ridge.

EM is taking steps to continue these trends and expects them to continue. During the last two years, EM has established a more focused investment strategy for science and technology. The new approach relies on four principles: solution-driven investing; full integration among cleanup projects; a comprehensive approach from science through deployment; and the use of credible decision processes. EM expects even greater benefits from its already successful science and technology program.

Implications of This Status Report

This status report has several broad implications:

1. EM will continue to implement an accelerated site closure and completion strategy. The results already achieved confirm the value of the strategy that EM began to pursue three years ago after determining that long-term program costs were too high and that excessive costs were spent on maintaining facilities rather than on direct cleanup. For sites in the closure part of the EM program, the current analysis continues to show that long-term costs have generally been reduced as a result of focusing on completing cleanup. Consequently, the EM policy of accelerating site closure and project completion should be continued and expanded while still protecting the environment and ensuring worker health and safety.
2. EM needs to consider applying site completion strategies to projects at sites with longer environmental missions. The data suggest that applying the project acceleration approach to projects at sites that have longer environmental missions may also be an effective strategy for the future. For example, the data show that at the low end of the range, EM expects to spend more than $20 billion in infrastructure and support costs. Although several EM sites will have complicated and challenging missions beyond 2006, these sites have many individual projects that are smaller, better understood, and very similar to those being accelerated at sites focused on closure. Where appropriate, EM may ask for additional resources to accelerate projects to achieve life-cycle cost savings.
3. Sites need to continue to improve their understanding of work scope and uncertainties, thereby allowing EM field offices and contractors to identify and deploy better project management approaches. As EM's understanding of the dimensions of a project improves, it can:

   - make better decisions about how to develop project plans, contingency estimates, and budget requests;
   - prioritize the work to be done; and
   - demonstrate the progress that Congress and stakeholders expect of this maturing program.

4. Some EM projects and baselines have achieved the levels of maturity needed to allow such project management approaches as fixed price contracting and privatization to move forward; others have not. EM must continue to emphasize the importance of better project management practices to make its life-cycle cost estimates more credible and more effective as long-term management tools.
5. All parties, including EM, its regulators, and stakeholders, must recognize that DOE and others should continue to explore new ways to think about the largest, most complex projects. Several large and complex projects will continue to be part of the EM program for many years. Some of these may ultimately require different project management approaches from those currently being implemented. All of these projects will benefit from additional scrutiny, investments in science and technology, and innovative technical and strategic approaches. EM will work closely with regulators, Tribal Nations, State and local officials, Congress, and other stakeholders to develop and implement such new approaches.
6. EM will continue to define and refine long-term stewardship requirements. In many cases, cleanup to allow unrestricted use of the land at all sites is simply not possible—EM does not have the technology nor is sufficient funding available. Consequently, DOE will be obligated to provide long-term stewardship activities at more than 100 sites after cleanup or disposal are complete. The Department is already performing long-term stewardship activities at 30 sites across the country where cleanup has been completed as well as at portions of larger sites. EM's challenge is to understand better its long-term stewardship obligations and associated costs more clearly, and to find ways to ensure that stewardship activities are safe, efficient, and sustainable. Meeting this challenge will require investing in science and technology to reduce costs and maintain effective stewardship. Finally, EM will need to work with stakeholders in developing an approach to long-term stewardship.

Conclusion

This status report reaffirms the benefits of pursuing the closure and completion strategy. Accelerating cleanup projects and closing sites creates a more efficient and cost effective EM program. EM plans to build on this record of accomplishment in reducing program costs for near-term (FY 2000 through FY 2006) projects. EM believes that applying this same strategy—along with other program improvements—to the remaining long-term projects and sites will further reduce program costs and enable EM to clean up more sites in less time.

APPENDIX A

Uncertainty Analysis Methodology

The objective of the uncertainty analysis conducted for this status report was to establish a reasonable range of life-cycle cost estimates using the sum of the individual project costs supplied by field offices as the starting point. Although some EM field offices account, where possible, for uncertainties at the project level, most do not. Therefore, EM developed a high-level range estimate to account for likely uncertainties across the entire EM program. Based on EM's experience and a literature review, there are three key factors that influence cost uncertainty in environmental projects:

Project definition, the most significant of these factors, represents the level of site-specific information and engineering included in an estimate. For example, a cleanup project cost estimate based on an agreed upon Record of Decision and a detailed engineering design would represent a higher level of project definition (and lower cost uncertainty) than a cost estimate based on limited information early in the scoping phase of a project. Industry standards explicitly recognize project definition as a major reason for project uncertainties. In fact, for projects still in a conceptual stage, cost estimators may typically use -50 to +125 percent as a reasonable first attempt to estimate project uncertainties; those in a detailed design stage may still have uncertainties of -10 to +25 percent. For a program expecting to last another 50 or more years, there are still many unknowns associated with project definition.

Innovation represents the extent to which a project relies on "tried-and-true" vs. new technical approaches. Projects with greater technical sophistication in the form of first-of-a-kind technologies are more likely to experience cost increases, but can also result in long-term cost reductions. The unique nature of EM's problems often necessitate technical innovation.

Complexity measures the number of process steps required to execute a project. Past analyses indicate that the more process steps there are in a project, the greater the level of cost uncertainty.

This cost uncertainty analysis assigns an uncertainty range for each Project Baseline Summary (PBS) by ranking it as having high, medium, or low uncertainty for project definition, innovation, and complexity. The analysis assigned initial uncertainty rankings for each category for each PBS. PBSs with high uncertainty in each of the three factors have the largest range of resultant cost uncertainties; projects with low uncertainty in each factor have the smallest range of cost estimates. PBSs without relevant data were assigned initial uncertainty rankings corresponding to medium uncertainty. DOE field offices reviewed the initial uncertainty rankings and made adjustments based on their site-specific knowledge of the remaining projects, and the extent to which cost uncertainties were already reflected in PBS cost estimates. This last adjustment was necessary since some of the changes in the baseline costs from last year to this year already reflected an improvement in project definition which reduced the need for an additional uncertainty component. Given the cost ranges for each PBS, the analysis then used a Monte Carlo simulation to develop a cost uncertainty range for the total life-cycle costs.

As each individual project becomes better defined in the future, the baseline component of the life-cycle estimate will be updated to reflect the fact that uncertainties have been factored into the project estimates. Because most of the increased costs represented by the range are associated with cleanup work beyond the 2006 time frame, future changes in the uncertainty component of the life-cycle estimate are likely to be associated largely with the post-2006 time frame. Eventually, the baseline estimate should converge with the overall range estimate.

APPENDIX B
Estimated Completion Dates and Field-Generated Project Cost Estimates

(Does not include estimates of project uncertainty)

State	Geographic Site	Sum of Field-Estimated Project Costs (a) ($ in millions of constant 1999 dollars)	Latest Estimated Completion Date (b) (Fiscal Year unless noted)	Notes
AK	Amchitka Island	(c)	2002 (d)	See footnote
CA	Energy Technology Engineering Center	187	2007	Previously estimated to close in 2006
CA	General Atomics	13	2000	
CA	General Electric Vallecitos Nuclear Center	20	2008	Previously estimated to close in 2005
CA	Geothermal Test Facility	1	1997	Closed in 1997
CA	Laboratory for Energy-Related Health Research (UC-Davis)	39	2004	Previously estimated to close in 2002
CA	Lawrence Berkeley National Laboratory	94	2003	
CA	Lawrence Livermore National Laboratory - Main Site	504	2007	Previously estimated to close in 2006
CA	Lawrence Livermore National Laboratory - Site 300	(e)	2008	Previously estimated to close in 2006
CA	Stanford Linear Accelerator Center	7	2002	Previously estimated to close in 2000
CO	Grand Junction Office	200	2001	Accelerated one year since 1998 estimate

CO	Rio Blanco Site	(c)	2007 (d)	See footnote
CO	Rocky Flats Environmental Technology Site	7,721 (includes post-closure costs)	Dec. 2006	Accelerated four years since 1998 estimate
CO	Rulison Site	(c)	2005 (d)	See footnote
FL	Pinellas Plant	202	1997	Closed in 1997
IA	Ames Laboratory	2	1999	Closed in 1999
ID	Argonne National Laboratory - West (at INEEL)	14	2001	Previously estimated to close in 2000
ID	Idaho National Engineering and Environmental Laboratory	21,402	2050	
IL	Argonne National Laboratory - East	112	2003	Previously estimated to close in 2002
IL	Fermi National Accelerator Laboratory	2	1997	Closed in 1997
KY	Maxey Flats Disposal Site	24	2003	Previously estimated to close in 2002; DOE has no control over schedule
KY	Paducah Gaseous Diffusion Plant	980	2012	Previously estimated to close in 2010, but new schedule does not include supplemental appropriations received in FY 2000 or increases requested in FY 2001 budget
MO	Kansas City Plant	114	2004	Previously estimated to close in 1999
MO	Weldon Spring Site	354	2002	
MS	Salmon Site	(c)	2002 (d)	See footnote
NJ	Princeton Plasma Physics Laboratory	16	1999	Closed in 1999
NM	Gasbuggy Site	(c)	2011 (d)	See footnote
NM	Gnome-Coach Site	(c)	2010 (d)	See footnote
NM	Inhalation Toxicology Laboratory	17	1997	Site is now considered complete
NM	Los Alamos National Laboratory	1,873	2015	Previously estimated to close in 2017
NM	Sandia National Laboratories - NM	284	2005	Previously estimated to close in 2001
NM	South Valley	6	1996	Closed in 1996
NM	Waste Isolation Pilot Plant	8,052	2039	Previously estimated to close in 2038; delay due to one year delay in schedule for opening

NV	Central Nevada Test Area	(c)	2009 (d)	See footnote
NV	Nevada Test Site	1,500	2014	
NV	Project Shoal Area	(c)	2008 (d)	See footnote
NV	Tonopah Test Range Area	(f)	2009	See footnote
NY	Brookhaven National Laboratory	274	2006	
NY	Separations Process Research Unit (Knolls Atomic Power Laboratory)	195	2014	
NY	West Valley Demonstration Project	1,927	2015	Previously estimated to close in 2005
OH	Ashtabula Environmental Management Project (RMI)	139	2005	Previously estimated to close in 2003
OH	Columbus Environmental Management Project - King Ave. (Battelle)	131	2000	Previously estimated to close in 1998
OH	Columbus Environmental Management Project -W. Jefferson (Battelle)	(g)	2005	
OH	Fernald Environmental Management Project	3,182	2006	Currently validated baseline reflects closure date of 2008. Committed to reducing cost and bringing schedule back to 2006 with planning level funding for FY 2002 through completion
OH	Miamisburg Environmental Management Project (Mound)	692	2004	Accelerated one year since 1998 estimate
OH	Portsmouth Gaseous Diffusion Plant	1,101	2013	Previously estimated to close in 2005, but new schedule does not include supplemental appropriations received in FY 2000 or increases requested in FY 2001 budget
SC	Savannah River Site	36,805	2038	
TN	Oak Ridge Reservation (Y-12, ORR, ETTP (K-25), ORNL)	6,490	2014	Previously estimated to close in 2013
TX	Pantex Plant	112	2002	

UT	Monticello Remedial Action Project	126	2001	
WA	Hanford Site	55,558	2046	
	Hanford Site	22,796		Hanford Site and Office of River Protection total to 55,558
	Office of River Protection	32,762		
-NA-	Multiple State Projects (including EM Headquarters)	17,767	-NA-	Program ($millions) – Program Direction (7,013) – Science and Technology (5,098) – All Other (Including HQ and Other National Programs Costs) (4,207) – Long-Term S&M/UMTRA (1,315) – Nevada Offsites (134)

(a) Life-cycle cost estimate presented represents the low end of estimated life-cycle cost range ($168 billion) without any consideration of uncertainties. EM now estimates the appropriate estimate of total life-cycle cost estimate to be $168 - $212 billion if costs for FY 1997 through FY 1999 are included ($151 - $195 billion if FY 1997 through FY 1999 are excluded).

(b) Estimated schedules for completing environmental management activities have been adjusted to be consistent with the FY 2001 budget request.

(c) Costs for all Nevada Offsites are included in the Multiple States Nevada Offsites row. The total for all sites is $134 million.

(d) EM is currently reviewing the site closure dates for the Nevada Offsites to determine what, if any, additional surface cleanup is required and whether the remaining site activities involve only subsurface characterization of groundwater contamination and /or long-term monitoring.

(e) Cost estimate included in estimate for LLNL - Main Site.

(f) Cost estimate included in estimate for Nevada Test Site.

(g) Cost estimate included in estimate for Columbus Environmental Management Project - King Ave.

Note: Life-cycle costs for the following sites are included with other projects (corresponding site completion dates). Costs for Sandia National Laboratories - CA (1999) are included with Sandia National Laboratories - NM. Costs for Site A/ Plot M, IL (1997) are included in the Multiple State Projects. Costs for the Center for Energy and Environmental Research (1998) are included in the Oak Ridge Reservation. Costs from the following UMTRA sites are included in the Multiple State Projects: Maybell, CO (1998); Naturita, CO (1998); New Rifle, CO (1997); Slick Rock Old North Continent, CO (1997); and Slick Rock Union Carbide, CO (1997). Two UMTRA sites, Belfield and Bowman, ND were delisted. DOE costs associated with FUSRAP sites have been excluded.

1 The EM program refers collectively to headquarters and the 12 operations/field offices that oversee implementation of EM's environmental projects. Throughout this report, the 12 offices are referred to as field offices.

2 This list does not include the sites in the Formerly Utilized Sites Remedial Action Program (FUSRAP) that are the responsibility of the U.S. Army Corps of Engineers.

3 Although active cleanup is complete, many of these sites still require long-term care because wastes remain in place or long-term remedies, such as treating contaminated groundwater, are ongoing. DOE recently estimated that 109 of its sites will require some form of long-term stewardship. A list of these sites can be found in From Cleanup to Stewardship (U.S. Department of Energy, Office of Environmental Management. Washington, DC: DOE/EM-0466, October 1999).

4 U.S. Department of Energy, Office of Environmental Management. The 1996 Baseline Environmental

Management Report. Washington, DC: DOE/EM-0209, June 1996.

5 U.S. Department of Energy, Office of Environmental Management. Estimating the Cold War Mortgage: The 1995 Baseline Environmental Management Report. Washington, DC: DOE/EM-0232, March 1995.

6 Ibid.

7 This estimate of life-cycle costs includes the approximately $17 billion in costs EM incurred in FY 1997 through FY 1999. This estimate is comparable to the 1998 Paths to Closure report, which also included costs incurred for these years. The estimated range of life-cycle costs yet to be incurred (or remaining life-cycle costs) is more accurately stated as approximately $151 - $195 billion, if the costs for FY 1997 through FY 1999 are excluded. The life-cycle estimate prepared by the DOE Chief Financial Officer and audited by the Inspector General excludes these already incurred costs.

8 U.S. Department of Energy, Office of Environmental Management. Accelerating Cleanup: Paths to Closure. Washington, DC: DOE/EM-0362, June 1998.

9 U.S. General Accounting Office. DOE's Accelerated Cleanup Strategy Has Benefits But Faces Uncertainties. Washington, DC: GAO/RCED-99-129, April 1999.

10 All numbers in the life-cycle cost range are rounded.

11 Based on the results of the uncertainty analysis conducted for this status report, EM believes a probable estimate of future life-cycle costs of the program is approximately $184 - $212 billion (including the FY 1997 through FY 1999 costs) or $167 - $195 billion (excluding the FY 1997 through FY 1999 costs). However, given the sum of the field-generated individual project estimates (i.e., $168 billion, or $151 billion after excluding FY 1997 through FY 1999 costs), EM has chosen to express its life-cycle cost range more broadly in this status report as extending from $168 - $212 billion (or $151 - $195 billion after excluding the FY 1997 through FY 1999 costs).

12 U.S. Department of Energy, Office of the Chief Financial Officer. Accountability Report: Fiscal Year 1999. Washington, DC: DOE/CR-0069, March 2000. (See also ftp://ftpsrv.doe.gov/dist/cr/fcrs/doe-ar.pdf.)